



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Cognitive bias modification training in adolescents: effects on interpretation biases and mood

Citation for published version:

Lothmann, C, Holmes, E, Chan, S & Lau, J 2011, 'Cognitive bias modification training in adolescents: effects on interpretation biases and mood', *Journal of Child Psychology and Psychiatry*, vol. 52, no. 1, pp. 24-32. <https://doi.org/10.1111/j.1469-7610.2010.02286.x>

Digital Object Identifier (DOI):

[10.1111/j.1469-7610.2010.02286.x](https://doi.org/10.1111/j.1469-7610.2010.02286.x)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Journal of Child Psychology and Psychiatry

Publisher Rights Statement:

©Lothmann, C., Holmes, E., Chan, S., & Lau, J. (2011). Cognitive bias modification training in adolescents: effects on interpretation biases and mood. *Journal of Child Psychology and Psychiatry*, 52(1), 24-32.

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



This is the authors' final version, also known as a postprint. ©Lothmann, C., Holmes, E., Chan, S., & Lau, J. (2011). Cognitive bias modification training in adolescents: effects on interpretation biases and mood. *Journal of Child Psychology and Psychiatry*, 52(1), 24-32.

Cognitive bias modification training in adolescents:
Effects on interpretation biases and mood

Claudia Lothmann^{1,2}, Emily A. Holmes³, Stella W. Y. Chan^{1,4}, Jennifer Lau¹

¹ Department of Experimental Psychology, Oxford University, UK

² Faculty of Psychiatry and Neuropsychology, Maastricht University, the Netherlands

³ Department of Psychiatry, Oxford University, UK

⁴ Department of Psychiatry, University of Cambridge, UK

Abstract

Background: Negative biases in the interpretation of ambiguous material have been linked to anxiety and mood problems. Accumulating data from adults show that positive and negative interpretation styles can be induced through cognitive bias modification (CBM) paradigms with accompanying changes in mood. Despite the therapeutic potential of positive training effects, training paradigms have not yet been explored in adolescents. **Methods:** Eighty-two healthy adolescents (aged 13-17 years) were randomly allocated to either positive or negative CBM training. To assess training effects on interpretation bias, participants read ambiguous situations followed by test sentences with positive or negative interpretations of the situation. Participants rated the similarity of these sentences to the previously viewed ambiguous situations. Training effects on mood, negative and positive affect were assessed using visual analogue scales before and after training. **Results:** After training, adolescents in the *negative* condition drew more negative and fewer positive interpretations of new ambiguous situations than adolescents in the *positive* condition. Within the positive condition, adolescents endorsed more positive than negative interpretations. In terms of mood changes, positive training resulted in a significant decrease in negative affect across participants, while the negative condition led to a significant decrease in positive affect among male participants only. **Conclusion:** This is the first study to demonstrate the plasticity of interpretation bias in adolescents. The immediate training effects on mood suggest that it may be possible to train a more positive interpretation style in youth, potentially helping to protect against anxiety and depressive symptoms.

Keywords: interpretation bias, adolescence, anxiety, mood, cognitive bias modification

Anxiety and mood problems are common in adolescence (Lewinsohn, Hops, Roberts, Seeley, & Andrews, 1993) and often persist into adulthood (Pine, Cohen, Gurley, Brook, & Ma, 1998). Prevention of later anxiety and depression relies on a better understanding of early risk mechanisms. Interpretation biases, the tendency to draw negative conclusions from ambiguous situations, are not only prominent characteristics of adult (e.g. Lawson, MacLeod, & Hammond, 2002; MacLeod & Cohen, 1993) but also of adolescent anxiety and mood disorders (e.g. Dearing & Gotlib, 2009; Taghavi, Moradi, Neshat-Doost, Yule, & Dagleish, 2000). Compared to healthy adolescents, highly anxious and depressed adolescents endorse more negative definitions of homophones - words which have both a negative and a neutral meaning, such as *die/dye* - and more often select words that resolve ambiguous scenarios in a negative direction (Dearing & Gotlib, 2009; Taghavi et al., 2000). Despite these findings, fundamental questions over cause and effect remain: do interpretation biases contribute to the development of anxiety and mood symptoms or are they merely mood-congruent effects on cognition?

To address this question, Mathews and Mackintosh (2000) developed a cognitive bias modification (CBM) paradigm to train healthy adults to draw positive or negative interpretations to ambiguous situations. In the training phase, participants read a series of ambiguous situations, one at a time, which ended with a word fragment for the participants to complete. In the positive CBM condition, these word fragments always resolved ambiguity in a positive direction; whereas in the negative CBM condition, these fragments always resolved the ambiguity in a negative direction. Following training, participants in the positive condition drew more positive and fewer negative interpretations of new ambiguous situations than those in the negative condition. Participants from the negative condition also reported higher levels of state anxiety after training (Mathews & Mackintosh, 2000). While the effects of CBM training on

interpretation biases have been well-replicated, its effects on reducing anxiety/negative affect and/or increasing positive affect have been somewhat less consistent (e.g. Holmes & Mathews, 2005; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Mathews & MacLeod, 2002).

Recent extensions of this research to subclinical and clinical groups yield further results that may inform therapeutic developments. Specifically, these studies suggest that (sub)clinical samples show significant reductions of negative interpretation biases, state anxiety and negative affect following positive training (Blackwell & Holmes, 2009; Hirsch, Mathews, & Clark, 2007; Mathews & Mackintosh, 2000; Mathews, Ridgeway, Cook, & Yiend, 2007; Murphy, Hirsch, Mathews, Smith, & Clark, 2007; Salemink, van den Hout, & Kindt, 2008; Teachman & Addison, 2007; Yiend, Mackintosh, & Mathews, 2005). Not only do these results show that changes in interpretation biases precede changes in mood, they also implicate new targets for psychotherapy.

Despite these encouraging results in adult populations, only three studies have extended this research to youth, more specifically to pre-adolescent children (Muris, Huijding, Mayer, & Hameetman, 2008; Muris, Huijding, Mayer, Remmerswaal, & Vreden, 2009; Vassilopoulos, Banerjee, & Prantzalou, 2009). Muris et al. (2008, 2009) demonstrated in two studies that interpretation biases can be induced in healthy children with a task requiring interpretations of hypothetical situations during an imaginary space journey. Neither study assessed mood. Moreover, the ecological validity of the task is questionable. To address this, Vassilopoulos and colleagues (2009) employed realistic vignettes to induce positive interpretation biases in socially anxious children. Results showed a significant reduction in negative interpretation bias, anxiety, and anticipated anxiety in children who received training versus those who did not. Taken together, these results suggest that interpretation bias modification is possible in pre-adolescent

children. Moreover, the latter study also shows the effectiveness of positive training on mood. However, it remains to be answered whether such training paradigms have similar effects in pubertal samples, where the risk for anxiety and mood problems is dramatically increased (Lewinsohn et al., 1993; Lewinsohn, Rohde, & Seeley, 1998). Given developmental differences in cognitive maturation between adolescents, adults, and children (Blakemore, 2006, 2008), we cannot necessarily expect the same pattern of results to emerge in response to training in adults and children as in adolescents.

To address this, the current study aimed to investigate the effects of positive *and* negative CBM on interpretation biases and changes in negative and positive affect in healthy adolescents (aged 13-17) using a modified version of the original adult CBM paradigm (Mathews & Mackintosh, 2000). To increase the ecological validity of training, ambiguous scenarios were developed and modified to increase their relevance to adolescents. Consistent with previous studies (Muris et al., 2008; Muris et al., 2009; Vassilopoulos et al., 2009), we hypothesised that negative bias modification would result in more negative interpretation of new ambiguous situations, increases in negative and decreases in positive affect, while the opposite would be true for positive bias modification.

Method

Participants

Eighty-two adolescents aged 13 to 17 years (mean age: 15.22 years, *SD*: 1.38, 53.7% females) were recruited from seven mainstream schools in Oxfordshire and Lancashire, UK. The majority of students (97%) had a Caucasian ethnic background. All participants were fluent in English. Adolescents who reported severe reading disabilities or diagnosed anxiety or mood disorders were excluded. Because of differences in each school's schedules, and a need to minimize

disturbance to these, recruitment methods varied across schools. In some, we recruited through whole school assemblies while in others we targeted specific classes through the class teacher. Informed consents were obtained from adolescents aged 16 years or above and from parents/legal guardians of younger adolescents. Adolescents under the age of 16 also provided written assent. Ethical approval was received from the Central University Research Ethics Committee of the University of Oxford.

Adolescents were randomly allocated to either a positive CBM ($n=41$) or negative CBM ($n=41$) condition. Prior to the first testing session, we generated a random sequence of *ones* and *twos* stratified for gender. We then assigned consecutive participants to either the positive (*one*) or negative (*two*) training condition. Groups did not differ according to gender, age, race, or trait anxiety (all $ps > .11$; **Table 1**). Due to a technical problem with recording participant responses, data are only available for 66 adolescents for the interpretation bias measure after training. Of these 32 received the positive and 34 the negative CBM. These adolescents did not differ from the whole sample ($N=82$) in terms of gender, age, trait anxiety, or baseline negative affect and positive affect (all $ps > .41$; further details on request). Analyses for training effects on change in interpretation bias were therefore based on 66 adolescents whereas training effects on mood were analyzed by including the whole sample ($N=82$).

Overview of task procedures

The overall procedure is shown in **Figure 1**. Prior to training all participants completed the Trait Anxiety Inventory for children (Papay & Spiegelberger, 1986) and engaged in a short ‘imagination’ exercise. Research shows that the use of imagery can enhance the effects of CBM (Holmes, Lang, & Shah, 2009; Holmes & Mathews, 2005). Children and adolescents have good imagery abilities and are able to employ imagery when instructed (Harris, 2000; Kosslyn, 1980;

Kosslyn, Margolis, Barrett, Goldknopf, & Daly, 1990). In the exercise we asked participants to close their eyes, imagine coming home after school and describe what they could see, hear, smell, taste, and feel. Once adolescents confirmed that they could ‘picture objects, events and feelings in their mind’, they were instructed to apply these principles during the computer task. Overall, adolescents reported no problems with image creation. A reminder imagery exercise, during which participants imagined biting into a lemon, was administered immediately before training.

Participants then underwent our adolescent-version of the CBM task which consisted of a training phase and a testing phase. Mood was assessed before training (T1), immediately after training (T2), immediately before the test (T3), and immediately after the test (T4). As residual changes in mood might confound group differences in interpretational style at the test phase, a *picture filler task* lasting 10 minutes was included between training and test phase to remove possible mood differences between groups. This task involved participants rating the pleasantness of 60 neutral pictures on visual analogue scales from ‘*very unpleasant* (0 cm) to ‘*very pleasant*’ (9.8 cm). After completion of all tasks, participants were fully debriefed by the experimenter. Participants in the negative CBM condition also received a brief version of the positive training to neutralize any potential negative effects of negative training.

Cognitive bias modification training

We employed a modified version of the original CBM paradigm for adults (Mathews & Mackintosh, 2000). During the *training* phase participants were presented with a series of ambiguous situations on a computer screen each ending with a word fragment. Participants were asked to complete the word fragment as quickly as possible by typing in the first missing letter. Completing the word fragment resolved the ambiguity of the situation, which led participants in

the positive CBM condition to draw positive interpretations and participants in the negative CBM condition to draw negative interpretations. After each item, participants were presented with a comprehension question, which emphasised the emotional meaning of the situation and could only be answered correctly if the ambiguous situation had been interpreted in the intended direction. This was followed by immediate feedback (for examples from the original paper, please see Mathews & Mackintosh, 2000).

To increase relevance for adolescents, we developed 50 new ambiguous situations relating to peer and romantic relationships and educational and recreational attainments (Collins, Welsh, & Furman, 2009; Pinkerton & Dolan, 2007; Ryan & Shim, 2008; Seeley, Stice, & Rohde, 2009; Sheeber, Hops, Alpert, Davis, & Andrews, 1997). An example of one scenario is: *It is the first day of term. Your new teacher asks everyone to stand up and introduce themselves. After you have finished, you guess the others thought you sounded...* This was followed by a positive or negative word fragment: *cl-v-r (clever)* or *st-p-d (stupid)*. Participants in the positive CBM condition completed the first while participants in the negative condition completed the second fragment. None of the adolescents tested struggled with these fragments. The comprehension question following this item was: *Do you feel unhappy with your introduction?* The correct answer was ‘Yes’ for participants in the negative condition and ‘No’ for those in the positive condition, which was followed by feedback about correctness (‘Correct!’ or ‘Wrong!’).

Ten ‘distractor’ scenarios were included to make the purpose of training less explicit. Five of these involved completion of word fragments that resolved ambiguity in the opposite direction of assigned training condition. That is, participants in the positive CBM condition completed five word fragments that resolved ambiguity in a negative direction and *vice versa* for participants in the negative CBM condition. The remaining five distractors involved word fragments that kept

the overall valence of the item neutral, for example: *'You are about to meet up with your friend. Just before you leave, he phones to say that he can't make it. You think that this is because he is feeling unwell (unwell)'*. Thus, a total of 60 scenarios were used during the *training phase*. These were presented in five blocks of 12 items containing 10 items in the direction of assigned condition (i.e. positive or negative), one neutral item, and one item in the opposite direction of assigned condition. Situations were presented randomly in each block. The task was self-paced. Participants were reminded to imagine the situations were happening to them at the beginning of each block.

Assessment of subsequent interpretation bias

During the *testing phase*, a further 10 ambiguous situations were presented, each starting with a title. Again, these items were developed specifically for adolescents. Adolescents were instructed to imagine that each situation was happening to them. They were also explicitly asked to pay attention to the title. This time, however, the word fragment did *not* disambiguate the situation; for example: ***'The end-of term prom: As one of the main organizers, you are asked to give a short speech at the end-of term prom. When the time comes you get on the stage. As you speak, you notice some of the students in the audience start to l--gh (laugh)'***. Likewise, the comprehension question did not emphasise the emotional meaning of the situation: *'Did you get to the stage to speak?'*. Immediately after, participants were given a *recognition test*. The title of the previously presented ambiguous situation ('The end-of-term prom') was presented at the top of the screen with four recognition statements. None of these statements used the exact words of the situations but yielded similar meanings. Two sentences comprised 'targets' depicting either a positive (*'As you speak, students in the audience start to laugh approvingly'*) or a negative interpretation (*'As you speak, students in the audience find your efforts laughable'*). The

remaining two sentences comprised ‘foils’, statements that were related to the emotional valence of the situations but also included information that was not explicitly given in the ambiguous situations (positive foil: *As you speak, students in the audience start to applaud your comments*, negative foil: *As you speak, students in the audience start to yawn*).

Participants were instructed to rate the similarity of each of these sentences to those presented during the test phase on a scale from 1 (very different in meaning) to 4 (very similar in meaning). Successful interpretation bias modification would be indicated if adolescents in the positive condition gave higher similarity ratings for positive targets than for negative targets; and likewise if adolescents in the negative training rated negative targets as more similar to previously viewed situations than positive targets (Mathews & Mackintosh, 2000). In the original paradigm foils were included to investigate whether training effects specifically altered interpretation styles or whether it facilitated general response biases to valenced material (i.e. the tendency to give higher similarity ratings to positive or negative information more generally). All items and questions were presented on a portable computer Acer ‘*Travelmate 4720*’ on a 14’’ screen with E-Prime 2.0 (Psychology Software Tools, 2007), which also recorded responses and reaction times.

Assessments of mood changes

To assess self-rated mood, we developed 12 visual analogue scales (VAS), measuring negative and positive affect. Items with high face-validity for each emotion were chosen from the state anxiety scale of the State/Trait Anxiety Inventory for children (Papay & Spiegelberger, 1986), and the Positive and Negative Affect Scales for children (PANAS-C) (Laurent et al., 1999), both of which have satisfactory psychometric properties (Laurent et al., 1999; Papay & Spiegelberger, 1986). Consistent with the finding that the high co-occurrence of anxiety and

depression (Lewinsohn et al., 1993) is mediated through nonspecific negative affect (Clark & Watson, 1991), four items for state anxiety (nervous, worried, anxious, and scared) and four items for depressed affect (sad, upset, miserable, and gloomy) were combined to index negative affect. Another four items assessed positive affect (happy, calm, cheerful, and energetic). The VAS were 9.8 cm long between ‘*not [emotion] at all*’ (0 cm) and ‘*very [emotion]*’ (9.8 cm). Participants indicated how they were feeling at the current moment by marking the line.

Statistical analyses

A 2x2x2 repeated measures ANOVA explored the effects of two between subject factors (Training group: positive vs. negative, Gender: male vs. female) and one within-subject factor (Valence: positive vs. negative) on similarity ratings for targets and for foils in SPSS 16.0 (Chicago, IL). Analyzing targets and foils separately is consistent with previous studies (e.g. Mathews & Mackintosh, 2000). Trait anxiety and age were included as covariates. Concerning targets, one participant was excluded as an outlier (similarity ratings > 3SD above the mean) (female, positive condition). These analyses were thus conducted on 65 adolescents. Likewise, a 2x2x2 repeated measures ANOVA was conducted on changes in negative and positive affect from before to after training with two between-subject factors (Training group, Gender) and one within-subjects factor (Time: T1 vs. T2). Again, trait anxiety and age were included as covariates. Significant interactions were followed-up with independent sample t-tests for between-group differences and paired sample t-tests, assessing within-group differences from before to after training for each training group separately. Trait anxiety, age, and gender were only included in follow-up analyses if they significantly modified the 2-way training-group-by-time interaction. Between-group differences in mood at all four time points (T1, T2, T3, and T4) and training performance were assessed with independent sample t-tests. Whenever assumptions

of normality or sphericity were violated, the non parametric equivalent for the independent sample t-test, the Mann-Whitney-U-test (test statistic U), was employed. These analyses were based on the whole sample ($N=82$).

Results

Group differences in interpretation bias

For targets, the full model with two between-subject factors (Training condition, Gender), one within subject factor (Valence), and two covariates (Trait anxiety, Age) revealed a main effect of Gender, $F(1, 59)=4.4$, $p<.04$, $\eta^2=.07$, and crucially, a significant Training-Group-by-Valence interaction, $F(1, 59)=24.24$, $p<.01$, $\eta^2=.41$. No other main or interaction effects were significant ($ps>.53$). Girls assigned higher similarity to all test items than boys. Compared to the negative training group, the positive training group rated positive targets as more similar, $t(63)=2.84$, $p<.01$, $r=.34$, and negative targets as less similar, $t(63)=-4.54$, $p<.01$, $r=-.5$, to ambiguous situations in the test phase. The positive group also rated positive targets as more similar to the situations than negative targets, $t(30)=-6.03$, $p<.01$, $r=.74$. This within-group effect did not emerge for the negative training group ($t(33)=1.14$, ns) (**Figure 2**).

For foils, the full model revealed only a significant Training-Group-by-Valence interaction, $F(1, 60)=5.57$, $p<.05$, $\eta^2=.09$. All other main and interaction effects were not significant ($ps>.53$). Post hoc analyses showed that the positive training group rated positive foils as more similar to the ambiguous situations than negative foils, $t(31)=-3.67$, $p<.01$, $r=.55$. None of the other between- or within group t-tests yielded significant findings (all $ps>.16$) (**Figure 2**).

Group differences in mood changes

For negative affect, the full model revealed a significant main effect for trait anxiety, $F(1, 76)=14.43$, $p<.001$, $\eta^2=.16$, a significant Trait-anxiety-by-Time interaction, $F(1, 76)=6.14$,

$p < .05$, $\eta^2 = .08$, and finally, the predicted Training-Group-by-Time interaction, $F(1, 76) = 4.12$, $p < .05$, $\eta^2 = .05$ (**Table 3**). Those with higher levels of trait anxiety reported more negative affect overall. However, individuals with higher trait anxiety also showed larger reductions of negative affect from before to after training, $r = .34$, $p < .01$. Post-hoc tests for the Training-Group-by-Time interaction revealed that for adolescents in the positive group, negative affect significantly decreased from before to after training, $t(40) = 2.73$, $p < .01$, $r = .40$, whereas it did not change for adolescents in the negative condition, $t(40) = -.64$, *ns*) (**Table 2**).

The complete model for positive affect revealed no main effects (all $ps > .05$) but a significant Gender-by-Group-by-Time interaction, $F(1, 76) = 5.03$, $p < .05$, $\eta^2 = .07$ (**Table 3**). Splitting this up for gender groups revealed a significant Group-by-Time interaction in boys, $F(1, 36) = 5.24$, $p < .05$, $\eta^2 = .15$: positive affect only decreased in those receiving negative training, $t(19) = 2.76$, $p < .05$, $r = .54$ but did not change in the positive CBM group, ($t(17) = -.24$, *ns*). This Group x Time interaction did not emerge for girls, $F(1, 76) = 1.2$, $p = .28$, *ns*. Instead, only a Trait anxiety x Time interaction emerged, $F(1, 40) = 4.24$, $p < .05$, $\eta^2 = .11$. Here, girls with higher trait anxiety showed smaller reductions of positive affect across time ($r = -.29$, $p = .06$, *ns*).

Overall, independent sample t-tests for mood differences between the groups at T1, T2, T3, and T4 were conducted to assess whether fundamental differences in mood could have confounded results from the test-phase. None of the comparisons revealed significant effects (all $ps > .24$) (**Table 3**).

Group differences on training task performance

Adolescents in the positive condition were significantly faster in completing word-fragments than were adolescents in the negative condition, $U = 247.00$, $p < .01$, $r = -.42$. Adolescents in the positive training condition were also more accurate ($Mdn = 95\%$) in response to comprehension

questions than adolescents in the negative training condition ($Mdn = 88\%$), $U=277.00$, $p<.01$, $r=.47$ (**Table 1**). To eliminate the confound that between-group differences in accuracy of responses to comprehension questions and therefore receipt of positive feedback during training would influence training-specific changes, percentage of correct responses was included as a covariate in the above analyses for interpretation bias. Percentage of correct responses to comprehension questions did not correlate with any of the mood measures, suggesting that it did not confound training specific mood changes.

Discussion

This study is the first to examine interpretation bias modification training in adolescents. As adolescent anxiety and mood problems predict later episodes in adulthood (Pine et al., 1998), studying the plasticity of cognitive biases in this age has important implications for understanding early risk mechanisms and developing targets for cognitive therapies. Our study yielded two key findings. First, our modified CBM training paradigm for adolescents successfully induced interpretation biases in the intended direction. Adolescents in the positive training condition endorsed more positive and less negative interpretations of new ambiguous situations than adolescents in the negative condition. This effect was not merely attributable to differences in mood as there was no group difference in mood immediately before the testing phase (T3). Second, positive training resulted in decreased *negative affect* across participants and negative training decreased *positive affect* but for boys only.

Our training effects on interpretations biases in adolescents extend previous data on healthy adults and children. Numerous studies have shown that positive and negative training induces group differences in the interpretation of new ambiguous situations presented immediately and even 24-hours after training (Holmes & Mathews, 2005; Mathews & Mackintosh, 2000; Muris et

al., 2008; Muris et al., 2009; Salemink, van den Houdt, & Kindt, 2007; Vassilopoulos et al., 2009; Yiend et al., 2005). This is the first study to replicate findings in a pubertal sample, suggesting that interpretation biases are plastic in this age range. While a significant training-group-by-valence interaction also characterized foils, these effects were weaker, perhaps suggesting that training affects interpretation specifically and not response bias in general. We also found that modification training alters positive as well as negative mood but like adult data, these trends were less consistent and more work will be needed to verify these.

The current results speak to the apparent effectiveness of the positive CBM relative to the negative CBM. First, adolescents in the positive condition were faster in completing word fragments and more accurate in their responses to comprehension questions during training. Second, within-group differences emerged among individuals receiving positive training such that significantly more positive than negative interpretations were drawn over new ambiguous situations. These within-group differences raise questions over the mechanisms through which positive training exerts its effects. Positive training could either *increase* the salience of positive relative to negative interpretations or *decrease* the salience of negative interpretations relative to positive interpretations, both of which would result in a greater difference between positive and negative interpretations. Disentangling these alternatives relies on baseline measures of interpretation bias. Consistent with the adult literature positive training effects on reduced negative affect were significant and promising, albeit smaller than effects on cognition.

These results need to be viewed in light of several limitations. First, we did not include a baseline measure of interpretation bias, because pre-exposure to the outcome variable (i.e. assessment of interpretation bias via ambiguous situations and recognition items *before* training) may encourage adolescents to anticipate the purpose of the test phase. However, this has limited

our ability to draw conclusions on whether training conditions actually induced *changes* in interpretation biases. Second, to ensure that we completed testing in an appropriate timeframe, we assessed mood changes using simple visual analogue scales. While these measures offer an initial indication of whether interpretation bias modification *can* affect mood in adolescents, they may be less valid than standardized questionnaires such as the PANAS-C (Laurent et al., 1999) or STAI-C (Papay & Spiegelberger, 1986). Use of these questionnaires in future studies will allow further extrapolations of adult findings to those in adolescents (e.g. Holmes et al., 2009; Holmes, Mathews, Dagleish, & Mackintosh, 2006; Mathews & Mackintosh, 2000). Third, because of a need to minimize disruption to each school's routines and schedules, our methods of recruitment across schools ranged from brief presentations at whole school assemblies to more targeted invitations aimed at specific classes organised by a school teacher. Therefore, obtaining an accurate and meaningful rate of participation was problematic. However the range of schools that we approached was diverse, suggesting that the recruited sample, though self-selecting is likely, was representative. Finally, timing constraints prevented more elaborate assessments of other background factors such as social class and life stress, which may also inform the sample's representativeness in future studies.

Regardless of these caveats, our results carry exciting implications for understanding the role of interpretation biases on subsequent pathological emotional development. Adult data have already begun to address the effects of training on stress reactivity. These data suggest that vulnerability associated with negative cognitive biases may be expressed by increasing *risks* for anxiety and mood problems in the presence of stress. These questions await investigation in youth.

More importantly, these findings also carry clinical implications, raising the questions of whether modification of interpretation biases using positive training can attenuate future negative outcomes. Promising findings in adults (Hirsch, Hayes, & Mathews, 2009; Holmes et al., 2009; Wilson, Macleod, Mathews, & Rutherford, 2006) and children (Vassilopoulos et al., 2009) demonstrate that vulnerable individuals show reduced anxiety and negative interpretation biases after positive training. Clearly, more research is warranted on the long-term effects of these changes, but potentially CBM could serve as a powerful adjunct to treatment, as a relatively simple and cost-effective tool. The possibility that CBM could be used to modify early-emerging negative biases as a preventative intervention among high-risk youth is especially intriguing.

In summary, this study has demonstrated that interpretation bias modifications in healthy adolescents is not only possible but also affects mood. These findings replicate previous research and suggest that a positive interpretation style immediately decreases negative affect. Future research should consider including standardized mood measures, pre-training assessment of baseline interpretation bias, and assessment of stress reactivity after training to gain further insight about the developmental and maintenance mechanisms underlying anxiety and mood problems in this high risk age group.

Acknowledgements

The authors are very grateful to schools and students who participated in this study. We greatly appreciated the help with data collection of Katie Lockwood, Kerrie Channer, and Emma Molyneaux and earlier discussion with Bundy Mackintosh about CBM.

Correspondence

Correspondence concerning this article should be addressed to Dr Jennifer Lau, Department of Experimental Psychology, Oxford University, UK. Phone: +44 1865 271 375. Email: jennifer.lau@psy.ox.ac.uk

References

- Blackwell, S. E., & Holmes, E. A. (2009). Modifying interpretation and imagination in clinical depression: A single case series using cognitive bias modification. *Under review*.
- Blakemore, S. J. (2006). Development of the adolescent brain: implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry*, 47(4), 296-312.
- Blakemore, S. J. (2008). The social brain in adolescence. *Nature Reviews Neuroscience*, 9, 267-277.
- Clark, L. A., & Watson, D. (1991). Tripartite model of anxiety and depression: psychometric evidence and taxonomic implications. *Journal of Abnormal Psychology*, 100(3), 316-336.
- Collins, W. A., Welsh, D. P., & Furman, W. (2009). Adolescent romantic relationship. *Annual Review of Psychology*, 60, 631-652.
- Dearing, K. H., & Gotlib, I. H. (2009). Interpretation of ambiguous information in girls at risk for depression. *Journal of Abnormal Child Psychology*, 37, 79-91.
- Harris, P. (2000). *The work of the imagination*. Oxford: Wiley-Blackwell.
- Hirsch, C. R., Hayes, S., & Mathews, A. (2009). Looking at the bright side: accessing benign meanings reduces worry. *Journal of Abnormal Psychology*, 118(1), 44-54.
- Hirsch, C. R., Mathews, A., & Clark, D. M. (2007). Inducing an interpretation bias changes self-imagery: a preliminary investigation. *Behavior Research and Therapy*, 45, 2173-2181.
- Holmes, E. A., Lang, T. J., & Shah, D. M. (2009). Developing interpretation bias modification as a "cognitive vaccine" for depressed mood: imagining positive events makes you feel better than thinking about them verbally. *Journal of Abnormal Psychology*, 118(1), 76-88.
- Holmes, E. A., & Mathews, A. (2005). Mental imagery and emotions: a special relationship? *Emotion*, 5, 489-497.
- Holmes, E. A., Mathews, A., Dagleish, T., & Mackintosh, B. (2006). Positive interpretation training: Effects of mental imagery versus verbal training on positive mood. *Behavior Therapy*, 37, 237-247.
- Kosslyn, S. M. (1980). *Image and mind*. Cambridge, Massachusetts: Harvard University Press.
- Kosslyn, S. M., Margolis, J. A., Barrett, A. M., Goldknopf, E. J., & Daly, P. F. (1990). Age differences in imagery abilities. *Child Development*, 61(4), 995-1010.
- Laurent, J., Catanzaro, S. J., Joiner, T. E., Rudolph, K. D., Potter, K. I., Lambert, S., et al. (1999). A measure of positive and negative affect for children: scale development and preliminary validation. *Psychological Assessment*, 11, 326-338.
- Lawson, C., MacLeod, C., & Hammond, G. (2002). Interpretation revealed in the blink of an eye: depressive bias in the resolution of ambiguity. *Journal of Abnormal Psychology*, 111, 321-328.
- Lewinsohn, P. M., Hops, H., Roberts, R. E., Seeley, J. R., & Andrews, J. A. (1993). Adolescent psychopathology: I. Prevalence and incidence of depression and other DSM-III-R disorders in high school students. *Journal of Abnormal Psychology*, 102(1), 133-144.
- Lewinsohn, P. M., Rohde, P., & Seeley, J. R. (1998). Major depressive disorder in older adolescents: prevalence, risk factors, and clinical implications. *Clinical Psychology Review*, 18(7), 765-794.

- Mackintosh, B., Mathews, A., Yiend, J., Ridgeway, V., & Cook, E. (2006). Induced biases in emotional interpretation influences stress vulnerability and endure despite changes in context. *Behavior Therapy, 37*, 209-222.
- MacLeod, C., & Cohen, L. (1993). Anxiety and the interpretation of ambiguity: a text comprehension study. *Journal of Abnormal Psychology, 102*, 238-247.
- Mathews, A., & Mackintosh, B. (2000). Induced emotional interpretation bias and anxiety. *Journal of Abnormal Psychology, 109*, 602-615.
- Mathews, A., & MacLeod, C. (2002). Inducing processing biases have causal effects on anxiety. *Cognition and Emotion, 16*(3), 331-354.
- Mathews, A., Ridgeway, V., Cook, E., & Yiend, J. (2007). Inducing a benign interpretational bias reduces trait anxiety. *Journal of Behavior Therapy and Experimental Psychiatry, 38*, 225-236.
- Muris, P., Huijding, J., Mayer, B., & Hameetman, M. (2008). A space odyssey: experimental manipulation of threat perception and anxiety-related interpretation bias in children. *Child Psychiatry & Human Development, 39*(4), 469-480.
- Muris, P., Huijding, J., Mayer, B., Remmerswaal, D., & Vreden, S. (2009). Ground control to Major Tom: Experimental manipulation of anxiety-related interpretation bias by means of the "space odyssey" paradigm and effects on avoidance tendencies in children. *Journal of Anxiety Disorders, 23*(3), 333-340.
- Murphy, R., Hirsch, C. R., Mathews, A., Smith, K., & Clark, D. M. (2007). Facilitating a benign interpretation bias in a high socially anxious population. *Behavior Research and Therapy, 45*, 1517-1529.
- Papay, J. P., & Spiegelberger, C. D. (1986). Assessment of anxiety and achievement in kindergarten and first- and second-grade children. *Journal of Abnormal Child Psychology, 14*, 279-286.
- Pine, D. S., Cohen, P., Gurley, D., Brook, J., & Ma, Y. (1998). The risk for early-adulthood anxiety and depressive disorders in adolescents with anxiety and depression disorders. *Archives of General Psychiatry, 55*, 56-64.
- Pinkerton, J., & Dolan, P. (2007). Family support, social capital, resilience and adolescent coping. *Child and Family Social Work, 12*, 219-228.
- Psychology Software Tools, I. (2007). *Psychology Software Tools*. Pittsburgh.
- Ryan, A. M., & Shim, S. S. (2008). An exploration of young adolescents' social achievement goals and social adjustment in middle school. *Journal of Educational Psychology, 100*(3), 672-687.
- Salemink, E., van den Houdt, M., & Kindt, M. (2007). Trained interpretive bias and anxiety. *Behavior Research and Therapy, 45*, 329-340.
- Salemink, E., van den Houdt, M., & Kindt, M. (2008). Effects of positive interpretive bias modification in highly anxious individuals. *Journal of Anxiety Disorders*.
- Seeley, J. R., Stice, E., & Rohde, P. (2009). Screening for depression prevention: identifying adolescent girls at high risk for future depression. *Journal of Abnormal Psychology, 118*(1), 161-170.
- Sheeber, L., Hops, H., Alpert, A., Davis, B., & Andrews, J. (1997). Family support and conflict: prospective relations to adolescent depression. *Journal of Abnormal Child Psychology, 25*(4), 333-344.

- Taghavi, M. R., Moradi, A. R., Neshat-Doost, H. T., Yule, W., & Dagleish, T. (2000). Interpretation of ambiguous emotional information in clinically anxious children and adolescents. *Cognition and Emotion*, 14, 809-822.
- Teachman, B. A., & Addison, L. M. (2007). Training non-threatening interpretation in spider fear. *Cognitive Therapy Research*, 32, 448-459.
- Vassilopoulos, S. P., Banerjee, R., & Prantzalou, C. (2009). Experimental modification of interpretation bias in socially anxious children: Changes in interpretation, anticipated interpersonal anxiety, and social anxiety symptoms. *Behavior Research and Therapy*, 47, 1085-1089.
- Wilson, E. J., Macleod, C., Mathews, A., & Rutherford, E. M. (2006). The causal role of interpretive bias in anxiety reactivity. *Journal of Abnormal Psychology*, 115, 103-111.
- Yiend, J., Mackintosh, B., & Mathews, A. (2005). Enduring consequences of experimentally induced biases in interpretation. *Behavior Research and Therapy*, 43, 779-797.

List of Tables and Figures

Table 1

Participant characteristics and training performance

Table 2

Negative and positive affect at time point 1 (T1), time point 2 (T2), time point 3 (T3), and time point 4 (T4)

Table 3

Main effects and interactions for differences in negative and positive affect from time point 1 (T1) to time point 2 (T2) and between group differences in mood at T1, T2, T3, and T4

Figure 1

Testing Procedures. CBMT = cognitive bias modification training. STAI-T-C = trait anxiety scale of the State/Trait Anxiety Inventory for Children, VAS = visual analogue scales.

Figure 2

*Similarity ratings for positive and negative targets and foils across training groups in the testing phase. ** $p < .01$. Higher similarity ratings indicated greater resemblance of the item to the ambiguous situation.*

Table 1

	Means (SD)	
	Positive Group	Negative Group
<i>Demographics</i>		
N	41	41
Age (years)	15.2 (0.23)	15.24 (0.21)
Gender [N (%)]	23 (56.1%) female 18 (43.9%) male	21 (51.2%) female 20 (48.8%) male
Ethnicity	90.2% white 9.8% other (mixed)	95% white 5% other (mixed)
Trait anxiety	36.07 (1.00)	34.54 (1.32)
<i>Gender and training performance for results on cognition (N = 66)</i>		
N	32	34
Gender [N(%)]	16 (50.0%) female 16 (50.0%) male	16 (40.7%) female 18 (59.3%) male
% correct	93.33 (1.12)	86.32 (1.8)*
RT word fragments (ms)	1737.02 (82.21)	2303.88 (161.31)*

Note. * $p < .01$ for between group difference; % correct = percentage of correctly answered comprehension questions during training; RT word fragments = average reaction time to fill in word fragments during training.

Table 2

		Mean (SD)			
		T1	T2	T3	T4
<i>Depressed affect</i>	Positive Group				
	All	2.10 (1.53)	1.79 (1.58)*	1.33 (1.49)	1.39 (1.59)
	Males	2.31 (1.57)	2.13 (1.80)	1.53 (1.98)	1.72 (2.04)
	Females	1.98 (1.52)	1.52 (1.37)	1.17 (0.96)	1.13 (1.10)
	Negative Group				
	All	1.67 (1.19)	1.73 (1.15)	1.36 (1.36)	1.34 (1.15)
	Males	2.77 (1.15)	1.98 (1.67)	1.55 (1.05)	1.31 (0.88)
	Females	1.58 (1.25)	1.49 (1.12)	1.17 (1.24)	1.30 (1.41)
<i>Positive affect</i>	Positive Group				
	All	6.39 (1.47)	6.23 (1.72)	6.17 (1.74)	6.12 (1.96)
	Males	6.14 (1.20)	6.20 (1.74)	6.14 (1.77)	6.14 (1.86)
	Females	6.59 (1.65)	6.26 (1.72)	6.20 (1.76)	6.11 (2.08)
	Negative Group				
	All	6.63 (1.59)	6.23 (1.72)	6.12 (1.68)	6.37 (1.86)
	Males	6.62 (1.49)	5.77 (1.74)*	5.46 (1.36)	5.84 (1.84)
	Females	6.62 (1.72)	6.68 (1.61)	6.75 (1.75)	6.88 (1.78)

Note . *p < .05 for change from T1 to T2 as determined with paired sample t-tests; T1 = before training; T2 = after training; T3 = after picture filler task; T4 = after recognition test. All values are given in cm on visual analogue scales. Higher values indicate that this emotion was experienced more.

Table 3

	NA	PA
<i>complete analysis for differences between T1 and T2 (main effects and interactions)†</i>		
time	$p = ns$	$p = ns$
group	$p = ns$	$p = ns$
gender	$p = ns$	$p = ns$
time x group	$F(1,76)=4.12^*$	$p = ns$
time x gender	$p = ns$	$p = ns$
time x group x gender	$p = ns$	$F(1,76)=4.26^*$
<i>independent sample t-tests for differences between groups</i>		
T1	$p = ns$	$p = ns$
T2	$p = ns$	$p = ns$
T3	$p = ns$	$p = ns$
T4	$p = ns$	$p = ns$

Note * $p < .05$, NA=negative affect, PA=positive affect. †Trait anxiety and age were entered as covariates

Figure 1

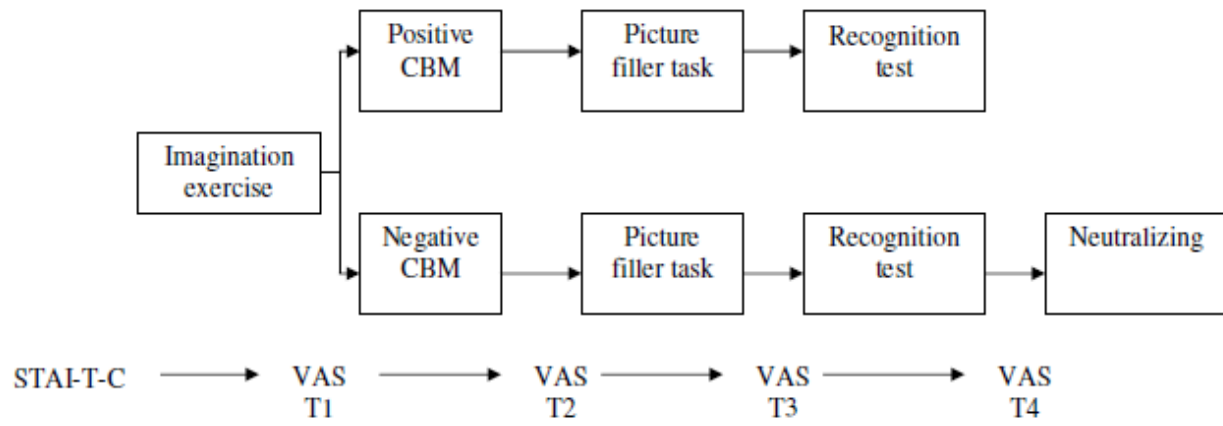
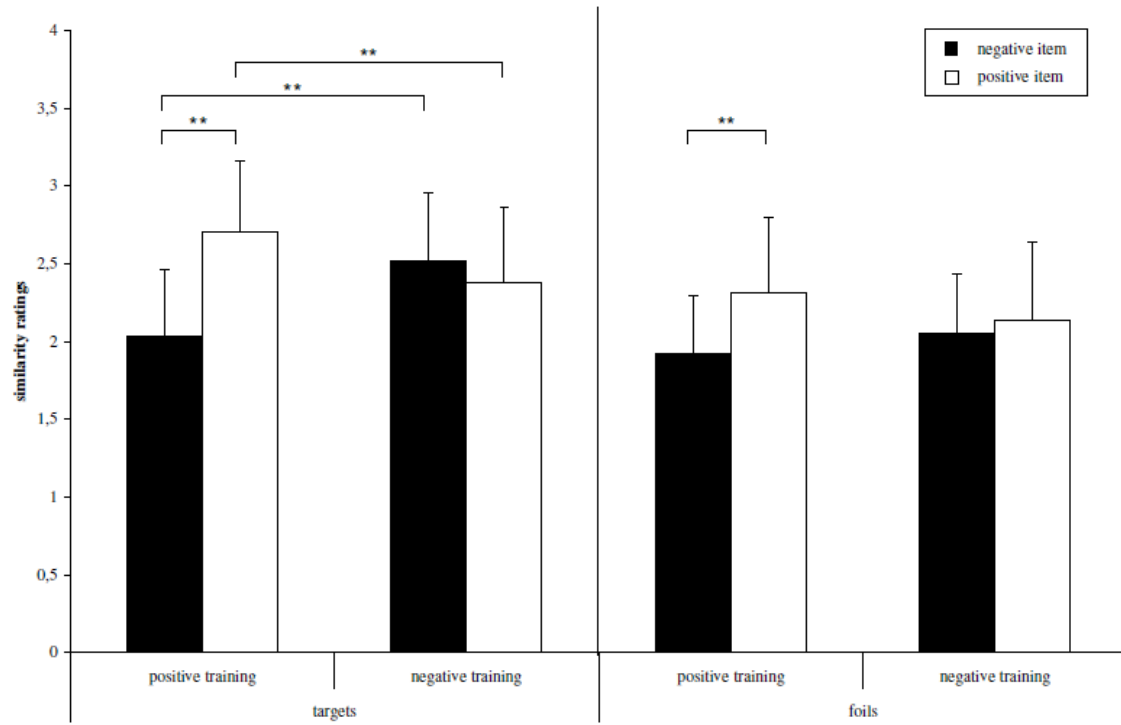


Figure 2



Key points

- Research in adults and children indicated that experimental manipulation of interpretation biases to ambiguous situations is possible and associated with changes in state anxiety and mood.
- Anxiety and mood problems are common in adolescence. This study therefore investigated the effects of an adolescent version of cognitive bias modification training on interpretation styles and mood.
- Results indicated that it is possible to manipulate interpretation of ambiguous social situations in healthy adolescents (age 13-17). Moreover, positive training resulted in a decrease in negative affect.
- That interpretation biases are plastic in adolescents has important theoretical and clinical implications for the development of preventive and early intervention programmes for anxiety and mood disorders in this high risk age range.